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Entrepreneurial Ecosystems: Analysing the Status Quo

PRE-PRINT VERSION

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Entrepreneurial Ecosystems: Analysing the Status Quo

Abstract: Entrepreneurial ecosystem research is an emerging field that prioritises in-depth discussions of the sustainable development of entrepreneurship. Scientometric analysis of the results of entrepreneurial ecosystem research helps understand the dynamics and development trends, providing new ideas for research on the sustainable development of entrepreneurial activities. This study conducts a quantitative examination of the development status of entrepreneurial ecosystem research using scientometric analysis and 286 articles focusing on entrepreneurial ecosystems. We identified the most influential institutions, authors, journals, references, betweenness centrality, as well as disciplines and topics in the field. Our paper summarises the literature on entrepreneurial ecosystem from the perspective of scientometrics, analyses the research dynamics, and provides a foundation for future research on entrepreneurial ecosystems.

Keywords: entrepreneurial ecosystem; scientometric; co-citation analysis

Subject classification codes: C10

1. Introduction

The entrepreneurial ecosystem which introduces ecological thought into the human socioeconomic order, is a new direction in entrepreneurial research. It refers to an interconnected group of actors in a local geographic community committed to sustainable development through the support and facilitation of new sustainable ventures (Cohen, 2006). Accompanied by the evolution of entrepreneurial behaviour, entrepreneurial ecosystem research involves the dual areas of ecological sustainable development and entrepreneurial management. As an emerging area in entrepreneurial research, the topic of entrepreneurial ecosystem must traverse a long journey before it officially enters the research field. Academic history has witnessed, two waves in the introduction of ecological thought into the study of human social order. The first wave occurred in the first half of the 20th century. The concept of ecology was applied to management, economics, and sociology. Tansley (1935) was the first ecologist to propose the concept of ecosystem: he introduced 'system' into ecological research, which defines ecosystem elements as a collection of complex organisms and habitat-related environments. The second wave, which started from Hanna and Freeman (1977), and systematically summed up the relationship between organisational type and environment from the perspective of organisational ecology (Michael and John, 1977). Scholars have simulated and empirically explored the competition and cooperation between population evolution and inter-industry. Ecological population theory is used to discuss the development path of environment through industrial development (Hannan et al, 1995). Research on such organisational evolution has similar conclusions

to that on the evolution of natural ecology, and scholars have applied it to in-depth research. With the development of society and an increasingly complicated economic structure, traditional entrepreneurial management theory cannot explain real-world dynamic entrepreneurial activities any longer. Ecological theory can use biological genetics, variations and selection mechanisms to compare the entrepreneurial ecosystem with the natural ecosystem, and present a better dynamic research framework for sustainable development of the entrepreneurial ecosystem. Although a new field, research on the entrepreneurial ecosystem has been rapidly progress, particularly in terms of defining the significance of the entrepreneurial ecosystem and evaluating the elements and functional characteristics of the entrepreneurial ecosystem.

As a new research field, there is significant interest in the development of the entrepreneurial ecosystem. Owing to the novelty of the topic, there were only 286 records of entrepreneurial ecosystem in the Web of Science Core Collection before March 2019, excluding Current Chemical Reactions (CCR-EXPANDED) and Index Chemicus (IC). However, it is obvious that the number of studies is rising, as Figure 1 shows.

Besides, more scholars from different countries are participating in related research. Authors from USA, England, Italy, Germany, Netherlands, Canada, Scotland, France, Australia, and China have contributed the most to achievements in the field. Therefore, the entrepreneurial ecosystem can exist in societies with different polities, economies, and cultures, and has high research value. Figure 2 shows the proportion of

different countries/regions in the overall literature on entrepreneurial ecosystem.

However, most of this literature is relatively new, without systematic bibliometric analysis. For a better understanding of the entrepreneurial ecosystem and the state of development of related research, this study conducts a scientometric analysis. Section 2 presents an introduction of the entrepreneurial ecosystem. Besides, the scientometric method is introduced, and the data source is confirmed. Section 3 then analyses the most influential institutions, authors, journals, references, betweenness centrality, as well as disciplines and topics.

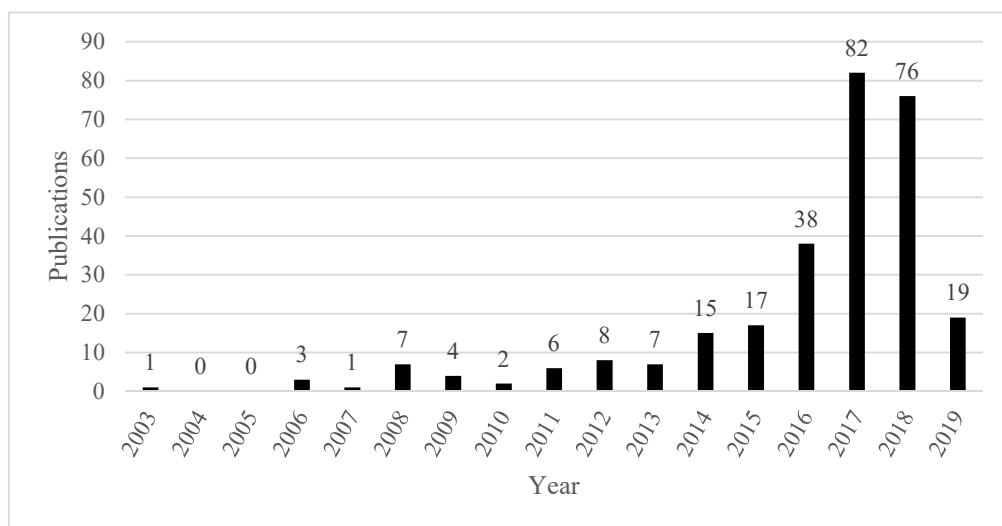


Fig. 1 Number of publications on the entrepreneurial ecosystem in Web of Science Core Collection

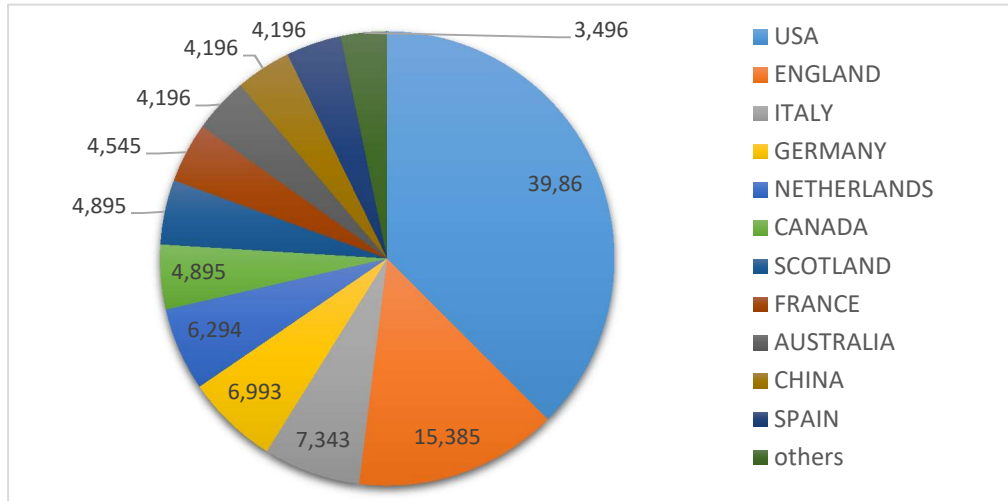


Fig. 2 Proportion of research literature from different countries/regions

2. Introduction to the Research on Entrepreneurial Ecosystem

2.1. Definitions

Spigel (2017) believes that entrepreneurial ecosystems represent the types of cultural, social, economic, and political environments within a region that support high-growth entrepreneurship. Moreover, they are seen as part of a regional economic development strategy based on creating supportive environments that foster innovative start-ups (Spigel, 2017). Scholars of the entrepreneurial ecosystem examine its connotation, especially the ecological characteristics of its sustainable development and network characteristics as a system of entrepreneurial management. First, the ecological characteristics of the entrepreneurial ecosystem are reflected in sustainable development with a spontaneous cycle. Spilling is the first author who proposed the concept of entrepreneurial ecosystem, and incorporated entrepreneurial activities in the market into a systematic system for research (Spilling, 1996). Moreover, entrepreneurial ecosystem was considered a three-part ecological environment in which relevant entities within a certain region play a decisive role in entrepreneurial activities. From the perspective of the university, Dunn puts forward the basic outline of the

entrepreneurial ecosystem and interprets the example of the Massachusetts Institute of Technology to understand the concept of the entrepreneurial ecosystem (Katharine, 2005). He believes that many organisations foster entrepreneurship within the entrepreneurial ecosystem. The entrepreneurial ecosystem has a spontaneous cycle, which is similar to the natural ecosystem, and can embody sustainability. Grobbelaar defines the entrepreneurial ecosystem as an ecosystem of synergistic symbiosis between science and technology, as well as innovation units and other innovative species, communities, and innovation environments (Sara, 2018). Promoting the development of the entrepreneurial ecosystem may benefit the local community (Sara, 2018). Second, defining the entrepreneurial ecosystem from the network perspective embodies the network system as a network resource allocation system. The entities are combined into an interdependent complementary system. The government and other powerful actors do not establish the entrepreneurial ecosystem; it is created by a network system formed by the daily interaction of common goals, resources and the main body of the infrastructure (Acs, 2018; Thompson, 2017). The focus in this definition is on the system stakeholders. The entrepreneurial ecosystem is a collaborative network of stakeholders in a specific entrepreneurial environment, in which entrepreneurial ecosystem participants, stakeholders, socioeconomic and political agents are playing the same important roles in creating economic value and solving social problems (Sarma and Sunny, 2017; Ben and Richard, 2018). The mutual competition and interests of multiple stakeholders embedded in the entrepreneurial ecosystem can aid in the emergence, prosperity and disappearance of the entrepreneurial ecosystem, and contribute to the sustainable development of the regional entrepreneurial ecosystem; thus, achieving the competitive aspects of sustainable economic growth (Jung, 2017; Carayannis, 2018).

2.2. Evaluation Research on Elements of Entrepreneurial Ecosystem

This aspect of study is an extension of the initial hierarchy of elemental structure classifications (Cohen, 2006) to measure and test the causal effects of ecological elements on entrepreneurial ecological output (Nicotra, 2018; Martha and Nataliya, 2018). Research on the entrepreneurial ecosystem has largely taken a macro-perspective to map the determinants of the entrepreneurial ecosystem better, while ignoring the research on its systemic elements (Cunningham, 2019). The research may only involve a brief description of the successful region, but it cannot be summarised. Therefore, the ecological elements of the entrepreneurial system can be used to measure the indicators of system health assessment more comprehensively. The key elements of the entrepreneurial ecosystem can identify emerging economies through system elements recognition, control key technologies and future market users, such as investment capital, skilled workers and entrepreneurial knowledge (Spigel and Harrison, 2018; Ferràs-Hernández, 2017). The interactive research in technical and network elements has gradually become a new research field of entrepreneurial ecosystem. Considering the non-equilibrium among the elements of the entrepreneurial ecosystem, the evaluation of its elements must focus on synergistic symbiosis and the spiralling of stakeholders within the system (Carayannis, 2018; Miller, 2016). In the process of factor evaluation, Auerswald combines the ecological characteristics of ecosystem and uses ecosystem vitality indicators to assess the vitality and development trajectory of a regional entrepreneurial ecosystem (Auerswald, 2017).

2.3. Functional Characteristics of the Entrepreneurial Ecosystem

The inductive functional characteristics of the entrepreneurial ecosystem focus on knowledge spillover function, incubator function, sustainable development function,

and innovative function. The first function is knowledge spillover. Schillo (2016) believes that Research-based Derivatives (RBSO) as agents of the entrepreneurial ecosystem determine the function of the knowledge spillover effects of the derivative company's on entrepreneurial ecosystem, and analyses the method to sustain economic growth and knowledge usage. The spilled knowledge ecosystems lead to the emergence of technology platforms, then the platforms react upon the entrepreneurial ecosystems and provide the resources they need (Schillo, 2016; Attour, 2018). The second function is to be an incubator. Colleges and universities engage in entrepreneurship and commercialisation, not only for students, but also for both students and teachers. Heodoraki analyses an important element of entrepreneurial support-the university business incubator-which plays an important role in the underlying entrepreneurial ecosystem in keeping the university sustainable (Huang-Saad, 2017; Heodoraki, 2018). The third function is innovation. Scholars define the entrepreneurial ecosystem while focusing on its innovative functions (Chao and Guan, 2017). Research on the entrepreneurial ecosystem leads to emerging technologies and their integration into complex technology systems and affects the new entrepreneurial ecosystem (Laguir and Den, 2016; Salter and McKelvey, 2016; Antonio, 2018). Moreover, innovation is reflected in available assets, freedom, and diversity as a frontier of the entrepreneurial ecosystem (Miller and Acs, 2017). The fourth function is that of sustainable development. Audretsch builds complex models based on entrepreneurial, regional and sustainability indices, and explores six areas of entrepreneurship (Audretsch and Belitski, 2017). Erina establishes an ecosystem model that contributes to regional sustainable development planning and design (Erina, 2017). The theory of sustainable development based on resource symbiosis is an important function of the entrepreneurial ecosystem. The emergence and sustainable diffusion of social

enterprises in the entrepreneurial ecosystem help the local entrepreneurial market satisfy the needs of self-circulation (Mcmullen, 2018; Debnath and Bardhan, 2018). The positive effects of the ecosystem on sustainable business models involves the impact of organisational-level factors (including type of risk and duration of venture investment) and individual-level factors (including types of network participants and their demographics) of social network connectivity. Thus, risk types and social network become a new element that affects the sustainability of the entire entrepreneurial ecosystem (Mustonen, 2018; Neumeyer and Santos, 2018).

In general, the ecological characteristics of sustainable development and the system network characteristics of enterprise management have become a significant direction in the defining entrepreneurial ecosystem research. Stakeholders in the entrepreneurial ecosystem form a synergy in the entrepreneurial environment. Research has expanded from the initial classification of elemental structures to the measurement and testing of the causal effects of ecological factors on the ecological output of the entrepreneurial ecosystem. The dynamic function of the development and self-circulation system ultimately promotes the sustainable development of the entire entrepreneurial ecosystem.

3. Method and Data

This study uses scientometric methods to analyse the cooperation network and research hotspots of entrepreneurial ecosystem research, which is common in the field of science research management (Chowdhury, 1998; Ying, 2011). A knowledge map is a scientometric tool, a type of measurement graph that shows the relationship between the scientific knowledge development process and structure. Chen Chaomei developed the Citespace information visualisation software using JAVA (Li and Chen, 2017).

Citespace can analyse the subject field evolution and scholar cooperation path through citation network and cooperative network visualisation, as well as find the turning point of high mediation centre, analyse evolutionary trends, and predict research frontiers (Chen, 2006). Citespace can transform the literature data into a knowledge map. It can display the size of the network node according to the frequency of the article. Each cluster formed by the nodes is composed of the cooperation or citation behaviour of a group of scientists with the same or similar research directions. This study primarily uses Citespace to explore and analyse the evolution, status, and frontier of entrepreneurial ecosystem research.

This study selects 286 articles from the Web of Science Core Collection from 2000-2019 (by March), excluding CCR-EXPANDED and IC, as CCR-EXPANDED and IC are for chemical indexes which are not related to entrepreneurial ecosystem research. A visual analysis confirms that the literature has a high level of academic value and strong representation. Since the entrepreneurial ecosystem is a relatively new research direction, this study also considers the CPCI-S database, because conference papers sometimes have high novelty.

4. Results

4.1. Institution Cooperation Network Analysis

The entrepreneurial ecosystem is a new field of research; therefore, the total number of research institutions is not large. Because there is no clear classification of their exploration, the links between institutions are not particularly obvious. Figure 3 shows the institution cooperation network for entrepreneurial ecosystem research. The larger the node, the more research results the institution has. The different colours in the nodes indicate the different years in which the new research occurred; a cluster is obvious among them. It includes Alpen Adria Univ Klagenfurt, George Washington University,

Natl Res Univ, Tech Univ Crete and Univ Appl Arts Vienna. These five institutions have relatively close cooperation in this field. According to the size of the node, the top institutions with the most research results are as follows: Indiana Univ, Univ Cambridge, Univ Utrecht, Univ Edinburgh, Arizona State Univ, Univ N Carolina, Univ Glasgow, George Mason Univ, Northumbria Univ, London Sch Econ and Stanford Univ.

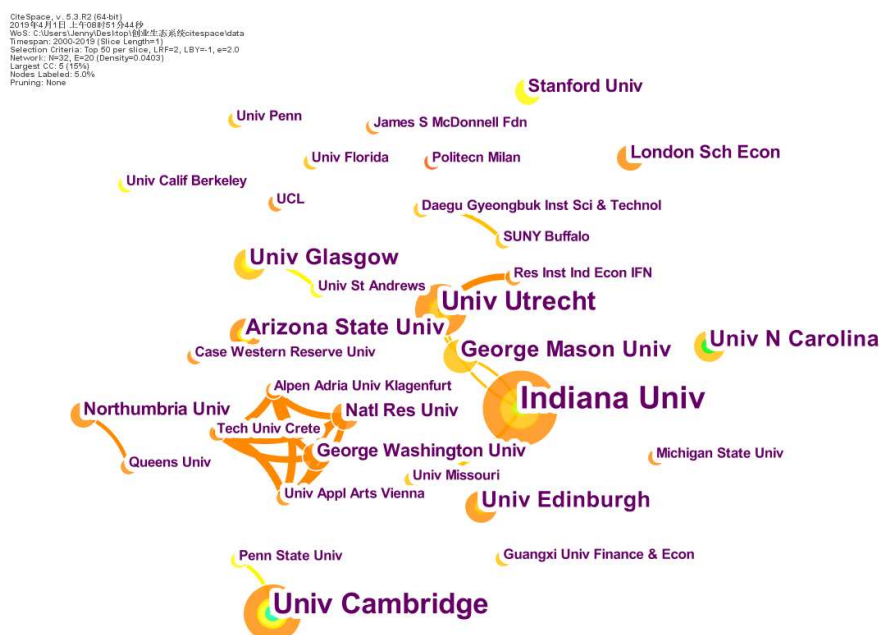


Fig. 3 Institution cooperation network

4.2. Author Co-citation Analysis

Co-citation analysis means that two documents appear in the same bibliography of the third citing document, and the two documents form a co-citation relationship (Li and Chen, 2017). Author co-citation analysis extracts author information from the entire bibliography. It can not only calculate the author's distribution in a certain field, identify scholars with influence in the field, but also excavate research topics. By analysing the author's common reference network and clusters, it identifies the distribution of similar authors and their subject areas in a certain field. Figure 4 shows the network of author co-citation. Nodes are coloured and labelled with different clusters, and the most cited authors are marked with black text. Six clusters are

Table 1 Authors with the most citations

| Citation counts | References | Cluster # |
|-----------------|--------------------|-----------|
| 63 | Audretsch DB, 2015 | 3 |
| 60 | Anonymous, 2011 | 6 |
| 59 | Acs ZJ, 2015 | 3 |
| 55 | Autio E, 2016 | 5 |
| 49 | Etzkowitz H, 2013 | 0 |
| 47 | Shane S, 2014 | 5 |
| 47 | Isenberg DJ, 2014 | 3 |
| 45 | Adner R, 2008 | 4 |
| 44 | Stam E, 2017 | 1 |

4.3. Journal Co-citation Analysis

The journal co-citation analysis is similar to the author co-citation analysis. It is used to establish a co-citation network from the source of the literature extracted from the references. The journal co-citation network shows the distribution of important knowledge sources in a field, which can help scholars identify the most cited journals in the field, and the links between these journals.

Figure 5 is the dual-map overlay of journal co-citation. The nodes on the left are citing journals, which are the application area of entrepreneurial ecosystem, and those on the right are cited journals, which are the foundation of entrepreneurial ecosystem. The curves indicate the relationship between citations and the strength of the curves indicate related to the amount of citations. The vertical axis of the ellipse represents the number of papers, and the horizontal axis represents the number of authors. It is obvious that the most cited documents and cited authors are the largest oval in the lower right corner, and the journal is *Research Policy*.

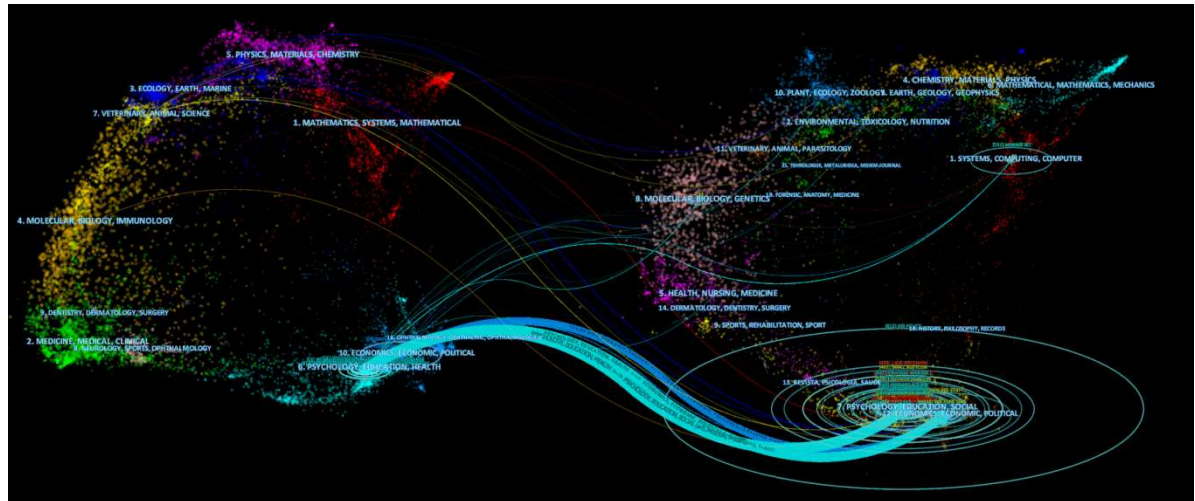


Fig. 5 Dual-map overlay of journal co-citation

Table 2 lists the clusters of journal co-citations and the top co-cited journals in each cluster. The closer the silhouette value is to 1, the higher it reflects the homogeneity of the network. When the value is greater than 0.5, the clustering result is reasonable; when the value is greater than 0.7, the clustering result has high reliability. Therefore, all the clusters in Table 2 are reasonable. Each cluster is labelled by keywords of citing articles in the cluster. The subsequent discussion use the labels chosen by the log-likelihood ratio test method. The largest cluster is #0, which is labelled *education*. The silhouette value is 0.687, and the most cited articles are from *Research Policy*. Therefore, *Research Policy* contributes the most cited articles. The second is labelled *universities*, with a size of 24; Cluster #2 is labelled *collaboration*, with a size of 24; *biopharmaceutical networks* is the fourth, with a size of 21; *university-business cooperation* is the label of Cluster #4 and *mitigation banking* is the label of Cluster #7.

Table 2 Clusters of co-citation and top citation counts of journals

| Cluster # | Size | Silhouette | Label | Source of literature | Citation counts |
|-----------|------|------------|-----------|----------------------|-----------------|
| 0 | 26 | 0.687 | education | RES POLICY | 154 |

| | | | | | |
|---|----|-------|------------------------------------|---------------------|-----|
| 1 | 24 | 0.688 | universities | EUR PLAN STUD | 57 |
| 2 | 24 | 0.663 | collaboration | STRATEGIC MANAGE J | 102 |
| 3 | 21 | 0.784 | biopharmaceutical networks | ACAD MREV | 112 |
| 4 | 18 | 0.633 | university-business cooperation | ENTREP THEORY PRACT | 117 |
| 5 | 7 | 0.923 | mitigation banking | SCIENCE | 19 |

4.4. Document Co-citation Analysis

Because entrepreneurial ecosystem is an emerging research field, this study sets one year as a time slice and selects all the articles from each time slice, from 2000 to 2019, to construct an individual network. All the individual networks are linked to obtain an overview of the whole development period. The study inserts all these references into the dataset. If the same article cites two papers, they are considered relevant. The link between them reflects their frequency of citations by the same article. The nodes in Figure 6 correspond to different publications, displayed using the three-ring method. The size of the node can reflect the number of times the node is cited or appears. The annual ring of the node represents the number of papers published in different years. The wider the annual ring of a year, the greater the frequency of quotation or appearance in the corresponding year. Figure 6 presents an overview of the network of knowledge map of entrepreneurial ecosystem. The co-cited references are connected tightly in the same cluster with the same colour. The top largest clusters are *entrepreneurial ecosystem*, *collaboration*, *entrepreneurship*, *entrepreneurial university*, *peripheral region*, *innovation policy*, *disruptive innovation*, *market and demand creation*, *incubators*.

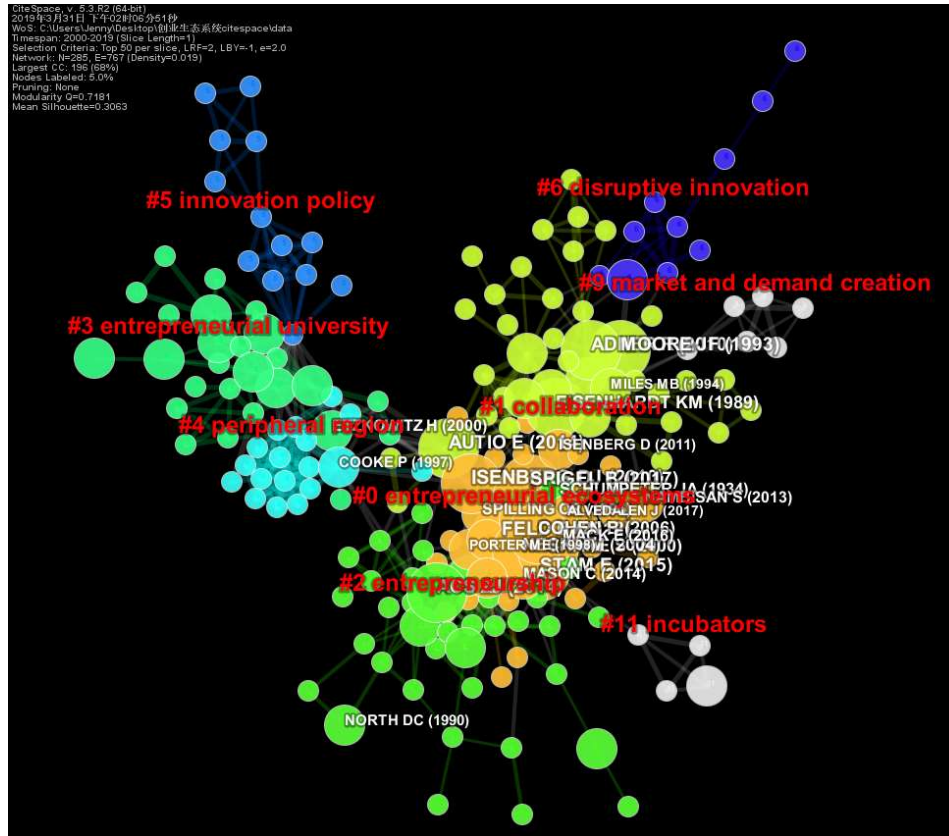


Fig. 6 Network of document co-citation

Table 3 shows the top 10 cited references of entrepreneurial ecosystem research. These references are from *HARVARD BUS REV* (Isenberg DJ, 2010), *STRATEGIC MANAGE J* (Adner R, 2010), *ENTREP THEORY PRACT* (Spigel B, 2017), *EUR PLAN STUD* (Stam E, 2015), *HARVARD BUS REV* (Moore JF, 1993), *RES POLICY* (Acs ZJ, 2014), *RES POLICY* (Autio E, 2014), *STARTUP COMMUNITIES* (Feld B, 2012), *ACAD MANAGE REV* (Eisenhardt KM, 1989) and *ACAD MANAGE REV* (Shane S, 2000). *Harvard Business Review* published the most cited article from Isenberg in 2010. It proposes nine prescriptions for creating an entrepreneurship ecosystem: stopping emulating silicon valley; shaping the ecosystem around local conditions; engaging the private sector from the start; favouring the high potentials; getting a big win on the board; tackling cultural change head-on; stressing the roots; not over-engineer clusters, helping them grow organically; reforming legal, bureaucratic, and regulatory

frameworks. It emphasised the importance of considering the overall entrepreneurial ecosystem.

Table 3 Top cited references

| Citation counts | References | Cluster # |
|-----------------|--------------------------------------|-----------|
| 35 | Isenberg DJ, 2010, HARVARD BUS REV | 0 |
| 33 | Adner R, 2010, STRATEGIC MANAGE J | 1 |
| 31 | Spigel B, 2017, ENTREP THEORY PRACT | 0 |
| 31 | Stam E, 2015, EUR PLAN STUD | 0 |
| 31 | Moore JF, 1993, HARVARD BUS REV | 1 |
| 31 | Acs ZJ, 2014, RES POLICY | 2 |
| 28 | Autio E, 2014, RES POLICY | 1 |
| 28 | Feld B, 2012, STARTUP COMMUNITIES | 0 |
| 27 | Eisenhardt KM, 1989, ACAD MANAGE REV | 1 |
| 25 | Shane S, 2000, ACAD MANAGE REV | 0 |

Table 3 shows that articles from Cluster #0, Cluster #1 and Cluster #2 occupy most of the top cited references, especially Cluster #0. Tables 4~6 list the key authors of Cluster #0, #1, #2 to indicate their research focus. This study selects three cited references with most cites and three citing articles with highest coverage.

Table 4 shows that three major citing articles, in terms of their citation coverage, are all published in 2017, which means Cluster #0 experienced rapid development in 2017. The article *Examining the connections within the startup ecosystem: a case study of St. Louis* has the highest coverage. This article critically examines the structure of entrepreneurial ecosystem using an exploratory and bottom-up approach, and applies a social network approach by analysing the connections of the ecosystem over multiple layers (Motoyama and Knowlton, 2017).

Table 4 Cited references and citing articles of Cluster #0

| Cited references | | | Citing articles |
|------------------|--|------------|--|
| Cites | Author (Year) Journal | Coverage % | Author (Year) Title |
| 35 | Isenberg DJ (2010) HARVARD BUS REV | 28 | MOTOYAMA, Y (2017) Examining the connections within the startup ecosystem: a case study of st. louis. |
| 31 | Spigel, B (2017) ENTREPRENEURSHIP THEORY AND PRACTICE | 22 | ALVEDALEN, J (2017) A critical review of entrepreneurial ecosystem research: towards a future research agenda. |
| 31 | Stam E (2015) EUR PLAN STUD | 22 | SPIGEL, B (2017) The relational organization of entrepreneurial ecosystem. |

As Table 3 shows, it is not difficult to find that articles in Cluster #1 account for nearly half of the top 10. This indicates that most people have focused on and cited the research of Cluster #1, and it has great academic value, which is probably the basis study of entrepreneurial ecosystem. Table 5 shows the top three cited references and citing articles in Cluster #1. The article *Business ecosystem and new venture business models: an exploratory study of participation in the lead to win job-creation engine* has the highest coverage value.

Table 5 Cited references and citing articles of Cluster #1

| Cited references | | | Citing articles |
|------------------|---|------------|---|
| Cites | Author (Year) Journal | Coverage % | Author (Year) Title |
| 33 | Adner R (2010) STRATEGIC MANAGE J | 17 | MUEGGE, SM (2017) Business ecosystem and new venture business models: an exploratory study of participation in the lead to win job-creation engine. |

| | | | |
|----|--------------------|----|--|
| 31 | Moore JF (1993) | 15 | FUSTER, E (2019) The emerging role of university spin-off companies in developing regional entrepreneurial university ecosystem: the case of Andalusia. |
| | HARVARD BUS REV | | |
| 28 | Autio E (2014) RES | 12 | ZHANG, C (2017) How to identify meta knowledge trends and features in a certain research field? Evidences from innovation and entrepreneurial ecosystem. |
| | POLICY | | |

Table 6 lists three articles that have the highest citation and coverage value in Cluster #2. The highest coverage value of a citing paper is 51%; over half of the cited references in the article *Looking inside the spiky bits: a critical review and conceptualization of entrepreneurial ecosystem* are related to this cluster. Therefore, there is high consistency between them. Notably, the citing documents with the highest coverage values in Cluster #0 and Cluster #2 both have the following article, *The relational organization of entrepreneurial ecosystem*. Thus, this article is the important intersection between these two clusters. The article argues that ecosystems are composed of 10 cultural, social, and material attributes that provide benefits and resources to entrepreneurs and the relationships between these attributes reproduce the ecosystem (Spigel, 2017). Looking back at Cluster #0, #1 and #2, the most widely citing articles essentially appeared in 2017, which shows that 2017 is the burst year of the research results.

Table 6 Cited references and citing articles of Cluster #2

| Cited references | | | Citing articles |
|------------------|-----------------------|------------|---------------------|
| Cites | Author (Year) Journal | Coverage % | Author (Year) Title |

| | | | |
|----|-------------------------------------|----|--|
| 31 | Acs ZJ (2014) RES POLICY | 51 | BROWN, R (2017) Looking inside the spiky bits: a critical review and conceptualization of entrepreneurial ecosystem. |
| 19 | Schumpeter JA (1934) THEORY EC DEV | 31 | SPIGEL, B (2017) The relational organization of entrepreneurial ecosystem. |
| 13 | North DC (1990) II CHANGE EC PERFOR | 5 | AUDRETSCH, DB (2017) Entrepreneurial ecosystem in cities: establishing the framework conditions. |

4.5. Disciplines involved in Entrepreneurial Ecosystem

As an emerging direction in the field of entrepreneurial research, the disciplines involved in the entrepreneurial ecosystem are relatively concentrated. Figure 7 shows the top 10 disciplines involved in the entrepreneurial ecosystem. They are *business & economy, management, business, engineering, economics, environmental sciences & ecology, public administration, regional & urban planning, environmental studies, engineering & industrial*.

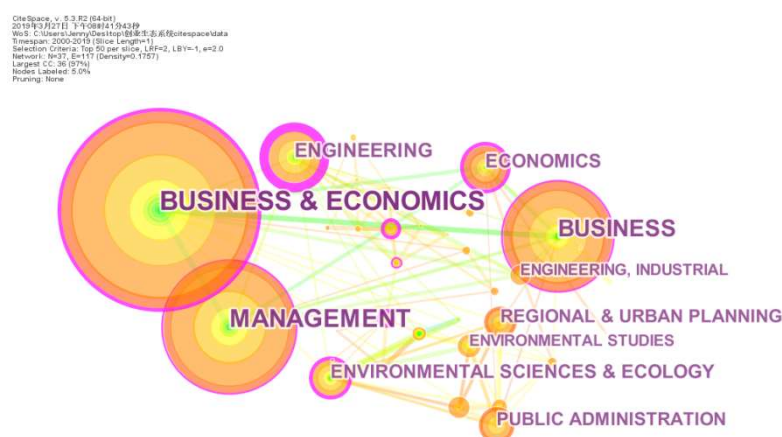


Fig. 7 Disciplines in the entrepreneurial ecosystem, shown as a network of subject categories.

Figure 8 shows the timeline of entrepreneurial ecosystem research. It shows that the five most important clusters can be summarised as *entrepreneurial individual, business plan, mitigation banker, disaster mitigation* and *patient capital*. Ecology and

environment science is the earliest discipline involved in entrepreneurial ecosystem. The nodes with the purple outer circle indicate that the literature on these areas contributes the most to entrepreneurial ecosystem research. Figure 8 shows nodes with purple circles as follows (arranged by time): *management*, *business and economics*, *engineering*, *science and technology*, *computer science*. With development, the research in entrepreneurial ecosystem has gradually appeared in several new fields in the past three years as follows: *computer science*, *education & educational research*, *public administration*, *information science & library science*, *communication*, *operations research & management science*, *geography*, *business and finance*.

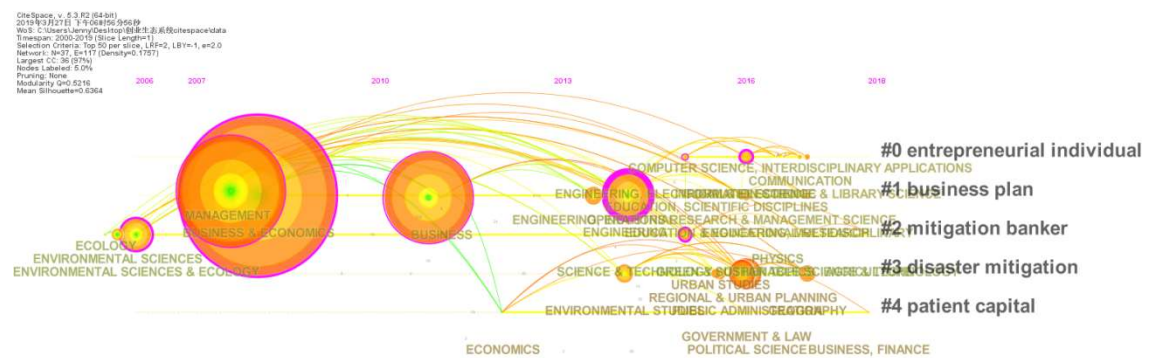


Fig. 8 Disciplines involved in entrepreneurial ecosystem, as a timeline

Table 7 shows the top 10 specific citation counts; half of them are related to Cluster #1 and last for a long time. Therefore, Cluster #1 plays the most important role in the entrepreneurial ecosystem. The lasted most cited fields concentrate in Cluster #3. Generally, Cluster #3 gathers emerging important fields.

Table 7 Specific citation counts in top disciplines

| Citation counts | Category, beginning of the year | Cluster # |
|-----------------|---------------------------------|-----------|
| 169 | BUSINESS & ECONOMICS, 2008 | 1 |
| 118 | MANAGEMENT, 2008 | 1 |
| 97 | BUSINESS, 2011 | 1 |

| | | |
|----|--|---|
| 46 | ENGINEERING, 2014 | 1 |
| 38 | ECONOMICS, 2012 | 4 |
| 35 | ENVIRONMENTAL SCIENCES & ECOLOGY, 2006 | 2 |
| 33 | PUBLIC ADMINISTRATION, 2016 | 3 |
| 30 | REGIONAL & URBAN PLANNING, 2016 | 3 |
| 22 | ENVIRONMENTAL STUDIES, 2014 | 3 |
| 21 | ENGINEERING, INDUSTRIAL, 2014 | 1 |

4.6. Topics involved in Entrepreneurial Ecosystem

The topics involved in entrepreneurial ecosystem can be delineated in terms of the keywords assigned to each article in the dataset. Figure 9 highlights the cluster result of the keywords, showing the hotspot distribution of entrepreneurial ecosystem. Table 8 lists the top 10 most counted keywords as follows: innovation, entrepreneurship, entrepreneurial ecosystem, performance, firm, knowledge, policy, industry, university and strategy. The 6 clusters are labelled as follows: *academic entrepreneurship*, *case study*, *start-up*, *incubator*, *ecosystem service* and *technology transfer*. Obviously, the research scope of the entrepreneurial ecosystem concentrates in the gathering place of *universities and startups*, and usually chooses the case study method. The clustering results shows that the research hotspots of the entrepreneurial ecosystem are relatively concentrated; the clustering results are not particularly significant, indicating that the research is not sufficiently mature. Furthermore, the focus of the existing results cannot form a normative branch. There is no dark connection between the keywords, indicating that research has been concentrated in recent years, further verifying the innovation in this field.

Table 9 lists the highest covered articles in every cluster. Cluster #1 is the largest cluster, and the most related reference is *Mission impossible? Entrepreneurial universities and peripheral regional innovation systems*. Besides, the clustering effect

of Cluster #5 (by silhouette) is the best. Industry, university, research and development, technology transfer, entrepreneurial university are the keywords in Cluster #5. The article with the highest coverage value is *Campus leadership and the entrepreneurial university: a dynamic capabilities perspective. Academy of Management Perspectives*. The article with the highest coverage cites the most references in the assigned cluster. In either Cluster #1 or #5, the research objects of the highest-covered articles are both universities, indicating that universities create entrepreneurial ecosystem easily.

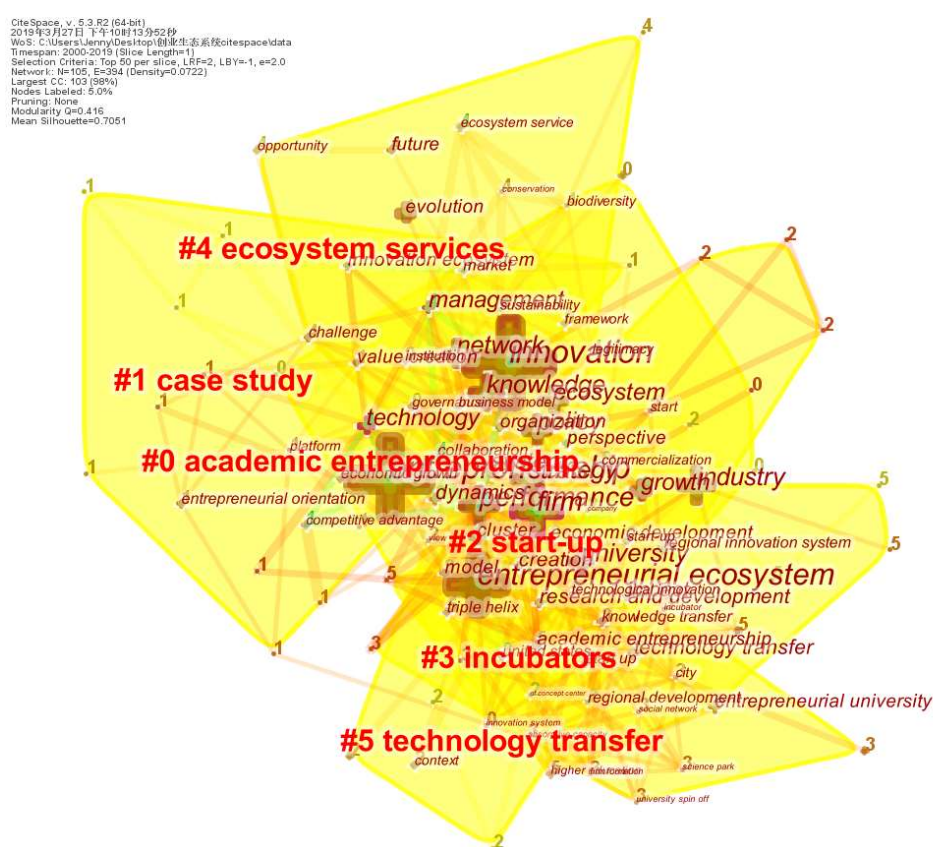


Fig. 9 Keywords co-occurrence clusters of entrepreneurial ecosystem

Table 8 Highest frequency of keywords and year of occurrence

| Counts | Year | Keywords |
|--------|------|---------------------------|
| 78 | 2008 | innovation |
| 71 | 2012 | entrepreneurship |
| 48 | 2014 | entrepreneurial ecosystem |

| | | |
|----|------|-------------|
| 43 | 2008 | performance |
| 38 | 2013 | firm |
| 30 | 2016 | knowledge |
| 29 | 2016 | policy |
| 26 | 2016 | industry |
| 25 | 2016 | university |
| 24 | 2016 | network |

Table 9 Clusters and bibliography

| Cluster # | Silhouette | Bibliography |
|-----------|------------|---|
| 0 | 0.636 | Brown, R (2016) Mission impossible? Entrepreneurial universities and peripheral regional innovation systems. Industry And Innovation, V23, P17 |
| 1 | 0.569 | Hannah, DP (2016) Resource redeployment in business ecosystem. Resource Redeployment And Corporate Strategy Advances in Strategic Management-A Research Annual, V35, P30 |
| 2 | 0.617 | Schaeffer, V (2016) Development of academic entrepreneurship in a non-mature context: the role of the university as a hub-organization. Entrepreneurship And Regional Development, V28, P22 |
| 3 | 0.69 | Di Fattah, D (2018) A relational view of start-up firms inside an incubator: the case of the arca consortium. European Journal Of Innovation Management, V21, P19 |
| 4 | 0.694 | Ben Letaifa, S (2016) How social entrepreneurship emerges, develops and internationalizes during political and economic transitions. European Journal Of International Management, V10, P12 |

| | | |
|---|-------|---|
| 5 | 0.729 | Leih, S (2016) Campus leadership and the entrepreneurial university: a dynamic capabilities perspective. Academy Of Management Perspectives, V30, P29 |
|---|-------|---|

Table 10 Top five frequency keywords in Cluster #5

| Counts | Year | Keywords |
|--------|------|----------------------------|
| 26 | 2008 | industry |
| 25 | 2012 | university |
| 14 | 2014 | research and development |
| 13 | 2008 | technology transfer |
| 11 | 2013 | entrepreneurial university |

4.7. Betweenness Centrality Analysis

The betweenness centrality (abbreviated in the following analysis as ‘centrality’) of a node in the network is a character which measures the importance of an article. In the visualisation, the purple circle is used for identification. In general, the higher the betweenness centrality, the more the importance of the literature. Articles with high betweenness centrality are key hubs connecting two different domains. Betweenness centrality is defined as a fraction of the shortest path of a given node divided by the number of shortest paths between any pair of nodes, as Equation 1 shows.

$$BC_i = \sum_{s \neq i \neq t} \frac{n_{st}^i}{g_{st}} \quad (1)$$

Where, g_{st} is the number of shortest paths from node s to node t , n_{st}^i is the shortest number of paths passing through node i in the shortest path from node s to node t .

Articles with high centrality are often the key hub connecting two different fields. Table 11 shows the top centrality references. The top ranked item by centrality is Isenberg DJ (2010) in Cluster #0, with centrality of 0.26. The second is Autio E (2014) in Cluster #1, with centrality of 0.21. The third is Grimaldi R (2011) in Cluster #3, with centrality of 0.21. The fourth is Eisenhardt KM (1989) in Cluster #1, with centrality of

0.17. The fifth is Cooke P (1997) in Cluster #4, with centrality of 0.15. The sixth is Adner R (2006) in Cluster #1, with centrality of 0.12. The seventh is Audretsch DB (2014) in Cluster #5, with centrality of 0.11. The eighth is Spigel B (2017) in Cluster #0, with centrality of 0.09. The ninth is Neck HM (2004) in Cluster #0, with centrality of 0.07. The tenth is Feld B (2012) in Cluster #0, with centrality of 0.06. In general, if the centrality value is greater than 0.1, the literature is more important. The higher the centrality, the more important it is. Therefore, as Table 11 shows, seven articles are more important, and three of them are even over 0.2. Isenberg notes that entrepreneurship can transform the economy; however, creating a breeding ground for new ventures is not simple (Daniel, 2010). Autio focuses on the relationships between contexts and entrepreneurial innovation, discusses policy implications, including how public and private actors can meet these challenges (Autio and Rannikko, 2016). Grimaldi considers the rationale for academic entrepreneurship and describes the evolving role of universities in the commercialisation of research (Rosa, 2011). Notably, in the development process of the entrepreneurial ecosystem, many studies focus on entrepreneurial universities. Research on entrepreneurial universities is an important component of entrepreneurial ecosystem.

Table 11 Citations with the highest centralities

| Centrality | References(author, year, journal, volume, page) | Cluster # |
|------------|---|-----------|
| 0.26 | Isenberg DJ, 2010, HARVARD BUS REV, 88, 40 | 0 |
| 0.21 | Autio E, 2014, RES POLICY, 43, 1097 | 1 |
| 0.21 | Grimaldi R, 2011, RES POLICY, 40, 1045 | 3 |
| 0.17 | Eisenhardt KM, 1989, ACAD MANAGE REV, 14, 532 | 1 |
| 0.15 | Cooke P, 1997, RES POLICY, 26, 475 | 4 |
| 0.12 | Adner R, 2006, HARVARD BUS REV, 84, 98 | 1 |
| 0.11 | Audretsch DB, 2014, J TECHNOL TRANSFER, 39, 313 | 5 |

| | | |
|------|---|---|
| 0.09 | Spigel B, 2017, ENTREP THEORY PRACT, 41, 49 | 0 |
| 0.07 | Neck HM, 2004, J SMALL BUS MANAGE, 42, 190 | 0 |
| 0.06 | Feld B, 2012, STARTUP COMMUNITIES, 0, 0 | 0 |

5. Conclusions

The analysis of the entrepreneurial ecosystem literature indicates its evolutionary trajectory from the conception proposed to the most recent knowledge. Scientometric analysis of the entrepreneurial ecosystem literature can help scholars understand the status quo. Cooperation network analysis enables the identification of primary cooperation networks in the research field. Whether it is the author or institution analysis in the cooperation network, it is important for resource sharing, exchange of ideas, and knowledge dissemination. Co-citation analysis of journals and documents can help scholars trace the research roots and identify trends in research and development. The analysis of disciplines and topics aids in finding the professional directions and hotspots involved in the entrepreneurial ecosystem. This is why some documents use the word ‘hotspot’ instead of ‘disciplines and topics’ for analysis. Betweenness centrality analysis can help scholars find the most important studies. Literatures streams with high betweenness centrality value are the key hubs that connect two different domains. The literature on high betweenness centrality value plays a crucial role in the research on entrepreneurial ecosystem and provides fertile ground for further investigations.

The detailed analysis above have led to the following conclusions:

- (1) The number of publications on entrepreneurial ecosystem increased every year, peaking in 2017.

- (2) The United States leads the research on entrepreneurial ecosystem, and institutions in the States contribute more publications than in other countries.
- (3) The most cited and highest centrality article in entrepreneurial ecosystem is *The Big Idea: How to Start an Entrepreneurial Revolution* published by *Harvard Business Review*. It proposes nine prescriptions for creating an entrepreneurship ecosystem: stopping emulating silicon valley; shaping the ecosystem around local conditions; engaging the private sector from the start; favouring the high potentials; getting a big win on the board; tackling cultural change head-on; stressing the roots; not over-engineering clusters, but helping them grow organically; and reforming legal, bureaucratic, and regulatory frameworks.
- (4) *Research Policy* has the most cited articles and the most cited authors, according to the journal co-citation analysis.
- (5) Based on document co-citation analysis, Cluster #0 is the largest cluster, labelled as entrepreneurial ecosystem. The reference *The relational organization of entrepreneurial ecosystem* appears in Cluster #0 and Cluster #2 (labelled entrepreneurship) simultaneously. That is, this reference bridges Cluster #0 and #2.
- (6) Business & Economics is the most involved discipline, followed by management and business.
- (7) Innovation, entrepreneurship and entrepreneurial ecosystem are the hottest topics, as indicated by keywords with the highest frequency.

Entrepreneurial ecosystem is an emerging research discipline, and low number of available documents caused difficulties in in-depth analysis. The research content is

also relatively scattered, making it difficult to identify possible directions and trends for future research. However, the sharp increase in the number of documents since 2017 indicates increasing attention from scholars. Thus, research on entrepreneurial ecosystems will continue to grow exponentially for a long time.

References

- Acs Z J, Estrin S, Mickiewicz T, Szerb L (2018) Entrepreneurship, institutional economics, and economic growth: an ecosystem perspective. *SMALL BUS ECON* 52: 501-514
- Antonio A, Ha-Joon C, Sue K, Alan S (2018) Introduction to the Special Issue: Towards a production-centred agenda. *CAMB J ECON* 42: 1495-1504
- Attour A, Lazaric N (2018) From knowledge to business ecosystem: emergence of an entrepreneurial activity during knowledge replication. *SMALL BUS ECON* 1: 1-13
- Audretsch D B, Belitski M (2017) Entrepreneurial ecosystem in cities: establishing the framework conditions. *J TECHNOL TRANSFER* 42: 1030-1051
- Auerswald P E, Dani L (2017) The adaptive life cycle of entrepreneurial ecosystem: the biotechnology cluster. *SMALL BUS ECON* 49: 97-117
- Autio E, Rannikko H (2016) Retaining winners: can policy boost high-growth entrepreneurship? *RES POLICY* 45: 42-55
- Ben S, Richard H (2018) Toward a process theory of entrepreneurial ecosystem. *STRATEG ENTREP J* 12: 151-168
- Carayannis E G, Grigoroudis E, Campbell D F, Meissner D, Stamati D (2018) The ecosystem as helix: An exploratory theory-building study of regional co-opetitive entrepreneurial ecosystem as Quadruple/Quintuple Helix Innovation Models. *R&D MANAGE* 48: 148-162
- Chao Z, Guan J (2017) How to identify metaknowledge trends and features in a certain research field? Evidences from innovation and entrepreneurial ecosystem. *SCIENTOMETRICS* 113: 1-21
- Chen C (2006) Citespace II: Detecting and visualizing emerging trends and transient patterns in scientific literature. *J ASSOC INF SCI TECH* 57:359–377
- Chowdhury G (1998) A Bibliometric Analysis of Collaboration in the Field of Information Retrieval. *INT INFORM & LIBR REV* 30: 367-376
- Cohen B (2006) Sustainable valley entrepreneurial ecosystem. *BUS STRATEG ENVIRON* 15: 1-14
- Cunningham J A, Menter M, Wirsching K (2019) Entrepreneurial ecosystem governance: a principal investigator-centered governance framework. *SMALL BUS ECON* 52: 545-562

- Daniel J I (2010) The Big Idea: How to Start an Entrepreneurial Revolution? HARVARD BUS REV 88: 40-56
- Debnath R, Bardhan R (2018) Resource Symbiosis Model through bricolage: A livelihood generation assessment of an Indian village. J RURAL STUD 60: 105-121
- Erina I, Shatreovich V, Gailesarkane E (2017) Impact of stakeholder groups on development of a regional entrepreneurial ecosystem. EUR PLAN STUD 25: 755-771
- Ferràs-Hernández X, Tarrats-Pons E, Arimany-Serrat N (2017) Disruption in the automotive industry: A Cambrian moment. BUS HORIZONS 60: 855-863
- Hannan M T, Dundon E A, Carroll G R, Torres J C (1995) Organizational evolution in multinational context: automobile manufacturers in Belgium, Britain, France, Germany, and Italy. AM SOCIOL REV 60: 509-528
- Heodoraki C, Messeghem K, Rice M P (2018) A social capital approach to the development of sustainable entrepreneurial ecosystem: an explorative study. SMALL BUS ECON 51: 1-18
- Huang-Saad A, Fay J, Sheridan L (2017) Closing the divide: accelerating technology commercialization by catalyzing the university entrepreneurial ecosystem with I-Corp. J TECHNOL TRANSFER 42: 1-21
- Jung K, Eun J H, Lee S H (2017) Exploring competing perspectives on government-driven entrepreneurial ecosystem: lessons from Centres for Creative Economy and Innovation (CCEI) of South Korea. EUR PLAN STUD 25: 827-847
- Katharine D (2005) Diversity Pledge. REVIEW 108: 15-19
- Laguir I, Den B M (2016) The influence of entrepreneur's personal characteristics on MSEs growth through innovation. APPL ECON 48: 4183-4200
- Li J, Chen C M (2017) Citespace: Text Mining and Visualization in Scientific Literature, 2nd ed. Capital University of Economics and Business Press, Beijing, pp 2
- Martha G R, Nataliya V S (2018) Leveraging complexity for ecosystemic innovation. TECHNOL FORECAST SOC 136: 114-131
- Mcmullen J S (2018) Organizational hybrids as biological hybrids: Insights for research on the relationship between social enterprise and the entrepreneurial ecosystem. J BUS VENTURING 33: 575-590
- Michael T H, John F (1977) The Population Ecology of Organizations. AM J SOCIOL 82: 929-964

- Miller D J, Acs Z J (2017) The campus as entrepreneurial ecosystem: the University of Chicago. *SMALL BUS ECON* 49: 1-21
- Miller K, Puthusserry P, McAdam R, Moffett S, Alexander A (2016) Knowledge transfer in university quadruple helix ecosystem: an absorptive capacity perspective. *R&D MANAGE* 46: 383-399
- Motoyama Y, Knowlton K (2017) Examining the Connections within the Startup Ecosystem: A Case Study of St. Louis. *ENTREP RES J* 28: 448-470
- Mustonen M, Matinmikko M, Holland O et al (2017) Process model for recent spectrum sharing concepts in policy making. *TELECOMMUN POLICY* 41: 391-404
- Neumeyer X, Santos S C (2018) Sustainable business models, venture typologies, and entrepreneurial ecosystem: A social network perspective. *J CLEAN PROD* 172: 4565-4579
- Nicotra M, Romano M, Giudice M, Schillaci C E (2018) The causal relation between entrepreneurial ecosystem and productive entrepreneurship: a measurement framework. *J TECHNOL TRANSFER* 43: 1-34
- Rosa G, Martin K, Donald S S (2011) 30 years after Bayh–Dole: Reassessing academic entrepreneurship. *RES POLICY* 40: 1045-1057
- Salter A J, McKelvey M (2016) Evolutionary analysis of innovation and entrepreneurship: Sidney G. Winter-recipient of the 2015 Global Award for Entrepreneurship Research. *SMALL BUS ECON* 47: 1-14
- Sara S G (2018) Developing a local innovation ecosystem through a university coordinated innovation platform: The University of Fort Hare. *DEV SO AFR* 35: 657-672
- Sarma S, Sunny S A (2017) Civic entrepreneurial ecosystem: Smart city emergence in Kansas City. *BUS HORIZONS* 60: 843-853
- Schillo S R (2016) Research-based spin-offs as agents in the entrepreneurial ecosystem. *J TECHNOL TRANSFER* 43: 222-237
- Spigel B (2017) The Relational Organization of Entrepreneurial Ecosystem. *ENTREP THEORY PRACT* 41: 49-72
- Spigel B, Harrison R (2017) Toward a process theory of entrepreneurial ecosystem. *Strategic Entrepreneurship Journal* 12: 151-168
- Spilling R (1996) The entrepreneurial system: On entrepreneurship in the context of a mega-event. *J BUS RES* 36: 91-103

- Tansley A G (1935) The Use and Abuse of Vegetational Concepts and Terms. *ECOLOGY* 16: 284-307
- Thompson T, Purdy J, Ventresca M J (2017) How Entrepreneurial Ecosystem Take Form: Evidence from Social Impact Initiatives in Seattle. *STRATEG ENTREP J* 12: 96-116
- Ying D (2011) Scientific collaboration and endorsement: Network analysis of coauthorship and citation networks. *J INFORMETR* 5: 187-203